Effects of long-term turfgrass management on soil nematode community and nutrient pools

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Abstract

The impact of long-term turf management practices on soil nematode abundance, community structure and soil nutrient pools were studied in replicated Kentucky bluegrass (*Poa pratensis*) plots maintained under nine different organic and inorganic management regimes for 15 years in Delaware, Ohio. After the application of inputs was stopped for one year, soil samples were collected in July and October. All free-living and plant-parasitic nematodes were identified to genus level and counted. Total nematode abundance, free-living nematode (FLN) abundance, plant-parasitic nematode (PPN) abundance, species diversity, richness, evenness, maturity index (MI), plant-parasitic index (PPI), combined maturity index (CMI), and FLN/PPN ratio were calculated. In addition, soil nematode faunal profile analysis was conducted to determine soil food web condition. NH_4-N, NO_3-N, dissolved organic nitrogen (DON), microbial biomass nitrogen (MBN), and soil organic matter (SOM) were measured to describe soil status. Results showed that in general, nematode abundance and food web indices were not differently affected by 9 management regimes. However, nematode community indices, MI and CMI, were significantly lower and Enrichment Index was significantly higher under high N-input compared to low N-input management. Herbicide, insecticide, or fungicide applications had no significant effect on nematode community in turfgrass soil ecosystem. Overall, the soil food webs were highly enriched but poorly to moderately structured in all management regimes. In addition, organic turf management resulted in higher soil microbial biomass compared to inorganic management or the control.

Introduction

- Lawns provide many benefits to the environment and society, such as minimizing soil erosion, contributing to carbon sequestration, reducing run-off and leaching, and providing spaces for recreation.
- Conventional lawn management relies heavily on fertilizers and pesticides, which may impair natural ecological processes in the lawn ecosystem and are also perceived to be sources of environmental pollution.
- However, due to extensive root growth and the continuous addition of clippings and nutrient inputs, lawn ecosystems are rich in organic matter and thus have high microbial biomass and activity, which can rapidly degrade chemical pesticides. Thus, we hypothesized that the application of herbicides, insecticides, and fungicides to turfgrass will not significantly affect soil microbial biomass or food web status.
- Nematodes are now widely used as bio-indicators for soil ecosystems as they function at almost every trophic level and react rapidly to contaminants and disturbances.
- A new model integrating nematode feeding groups and the *colonizer-persister* scale into a matrix classification of functional guilds can be used to assess soil food web structure and health. Enrichment Index (EI) and Structure Index (SI) are the two key components of this model. Based on this model, we hypothesized that the amount of nitrogen fertilizer input will affect soil nematode community and food web health.
- Due to the fact that organic management practices are becoming attractive, we also tested whether organic input management improves turf soil ecosystem conditions over inorganic input management.

Materials and Methods

Plot information: 2.4 m by 1.2 m. 4 replications for each management regime. Located at the TruGreen ChemLawn Research Center in Delaware, OH.
Turfgrass species: Kentucky bluegrass (*Poa pratese*).
Soil type: Blount Clay/Silt Loam

Management regimes: 1) Control, 2) Organic, 3) Organic + Weed Control, 4) All Nutrient, 5) Weed-N-Feed, 6) Estate, 7) Showplace Liquid, 8) Showplace Dry, 9) Scotts 4 Step.

Pre-emergent herbicide was included into regimes 5-9; broadleaf herbicide into 3 and 5-9; insecticide into 9; fungicide into 6; and fertilizer was added to all except the Control.

The following groups were summarized from the original 9 management regimes: A) control, low-N input (regime 5) and high-N input (regimes 2-4 and 6-9); B) control, organic management (regimes 2 and 3) and inorganic management (regimes 4-9); C) control, no herbicides (regimes 2 and 4) and with herbicides (regimes 3 and 5-9); and D) no-input control and regimes with inputs.

Soil sampling: 3cm-diameter soil probe, to a depth up to 15cm. Sampling time: July and October 2004.

Data collection and analysis:

Nematode community-- nematode abundance, free-living nematode (FLN) abundance, plant-parasitic nematode (PPN) abundance, FLN/PPN, nematode species richness, diversity, and evenness index, Maturity Index (MI), Plant-parasitic Index, Combined MI (CMI), Enrichment Index (EI), and Structure Index (SI).

Soil clay, sand, and silt content.

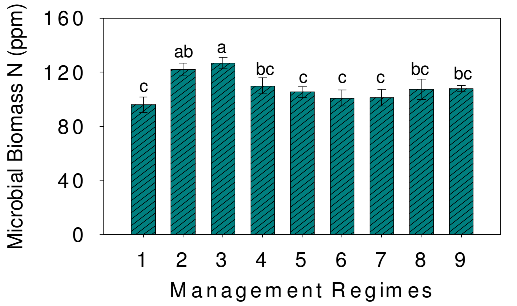
Soil nutrient pools– ammonia nitrogen, nitrate nitrogen, dissolved organic nitrogen, microbial biomass nitrogen (MBN), and soil organic matter (SOM).

Statistical analysis: since there was no significant difference between July and October data, they were pooled to run analysis of variance (PROC GLM, SAS Release 9.1, SAS Institute, Cary, NC) for the original 9 regimes and derived management groups. Fisher LSD was used for mean comparisons.

Results

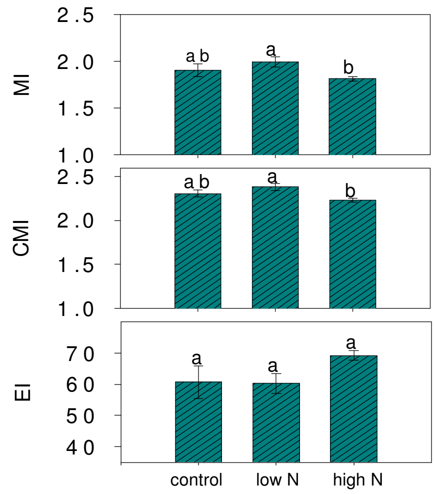
Nematode community was not significantly different among 9 management regimes (graphs not presented here). Microbial biomass N (MBN) differed significantly in 9 regimes overall, where Organic + Weed Control had significantly higher MBN than all other regimes except Organic that did not include weed control (Fig.1).

Fig. 1. Significantly different effects of management regimes on microbial biomass N in turf soil ecosystem.



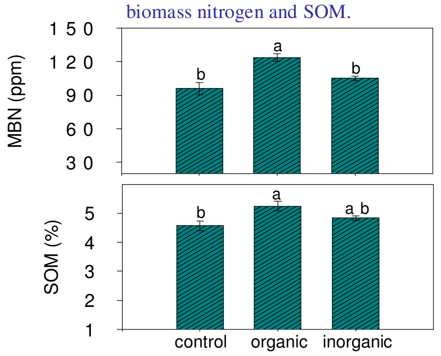
Management group analysis revealed the following results. MI and CMI were significantly higher under low N input compared to high N input management, while EI was significantly higher under high-N compared to low-N input management (for EI, ANOVA p value=0.0266, although LSD mean comparison didn't reveal significant difference) (Fig. 2).

Fig. 2. Significantly different effects of low N and high N management on nematode indices MI, CMI and EI.



Organic management resulted in significantly higher microbial biomass nitrogen (MBN) compared to inorganic management and the control. Also, organic management resulted in significantly higher soil organic matter (SOM) compared to the no-input control, while inorganic management did not (Fig. 3).

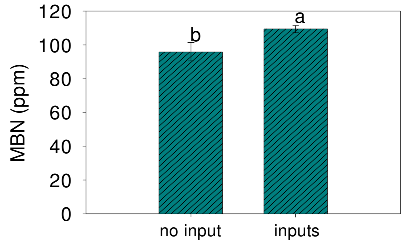
Fig. 3. Effects of organic and inorganic management on microbial biomass nitrogen and SOM.



MBN under no input management (the control) was significantly lower than MBN under management with inputs (Fig. 4).

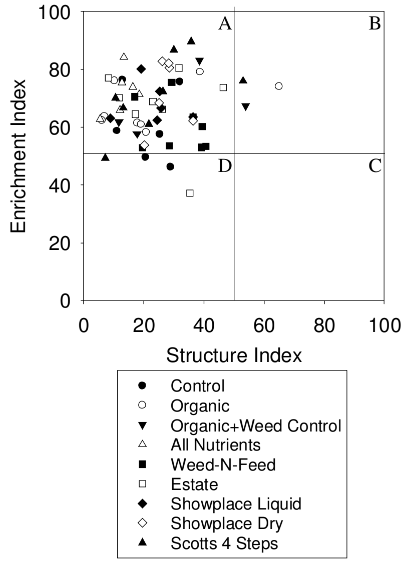
In addition, nematode community indices and soil nutrient status were not significantly affected by application of herbicides, fungicides, and insecticides (data not presented here).

Fig. 4. Significant effect of inputs on microbial biomass nitrogen compared to the no-input control.



Nematode community analysis showed that most food webs fall into Quadrat A in the model, few into B and D, indicating that food webs are highly enriched and poorly to moderately structured (Fig. 5).

Fig. 5. Nematode food web conditions deduced from faunal analysis under different turfgrass management regimes.



Discussion and Conclusions

Using nematode community as bio-indicator, results from our study suggest that turf soil ecosystems are relatively resistant to the application of insecticides, fungicides, and herbicides, which may result from high organic matter enrichment and high microbial activity in this system.

Organic management in this study further promoted soil microbial biomass and activity in turfgrass systems, although it had no significant effect on nematode community.

Nitrogen fertilizer input levels showed significant impact on turf soil nematode food web conditions, reducing Maturity Index and Combined Maturity Index, and increasing Enrichment Index in our study.

Overall, food webs in managed turfgrass soil systerms are evaluated as highly enriched and poorly to moderately structured, indicating a disturbed food web compared to natural grasslands and forest ecosystems.

Acknowledgements

We thank David McCartney, Donald Beam, and Senetta Bancroft for their help with soil nutrient analysis. Assistance from Dr. David Shetlar, Dr. Douglas Richmond for sampling, and Dr. Ganpati Jagdale, Mamta Singh, and Shabeg Briar for nematode identification is also gratefully acknowledged. This research was funded by the Ohio Lawn Care Association, Ohio Turfgrass Foundation, and the Urban Landscape Ecology Program.

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